

Application No. 10/089,578  
Filed: August 12, 2002  
TC Art Unit: 1754  
Confirmation No.: 2516

#### REMARKS

Claims 1-25 are pending in the present application. Claims 1, 3, 6-7, 10-17 and 24 are amended herein. New claims 26-34 are added. Accordingly, claims 1-34 will be pending upon entry of the instant amendments.

Support for the claim amendments can be found throughout the specification and claims as originally filed. Amendments to claims 1, 3, 6-7, 10-17 and 24 are made in response to 35 U.S.C. §112, second paragraph, rejections as further explained below. Support for the new claim 26 can be found, at least, for example, on page 8, lines 21-25, and on page 10, lines 23-26. Support for the new claims 27-33 can be found, at least, for example, from original claims 1, 7 and 10-17. No new matter has been added.

Any amendments to the claims should in no way be construed as acquiescence to any of the Examiner's rejections and were done solely to expedite the prosecution of the application. Applicant reserves the right to pursue the claims as originally filed in this or a separate application(s).

#### Claim Rejections - 35 U.S.C. §112

Claims 1-25 are rejected under 35 U.S.C. §112, second paragraph, as being indefinite.

Applicants have appropriately amended the claims to overcome the foregoing rejection thereby making them clear and definite. Claim 1 was amended to clearly recite that the process of sulphur dioxide is to reduce ultimately to elemental sulfur (Paragraph "a)" and "b)", page 2 of the Office Action). Claims 1, 7, 13-17 and 24 were amended to delete the phrase "preferably" thereby making them clear and definite (§ "c)", p. 2). Claims 6 and 10-12

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were amended to delete the phrase "such as" thereby making them clear and definite (§ "d)", p. 3). Claim 3 was amended to recite the actual elements as suggested by the Examiner (§ "e)", p. 3). Accordingly, Applicants respectfully request reconsideration and withdrawal of the foregoing rejection.

Claim Rejections - 35 U.S.C. §103

Claims 1-25 are rejected under 35 U.S.C. §103(a) as being obvious over Groenendaal et al., U.S. Patent 3,947,547 (the '547 patent), in view of Kohl et al., *Gas Purification* (4<sup>th</sup> ed.), pages 421 and 422.

Applicants respectfully traverse the foregoing rejection.

The present invention is directed to a process for the catalytic reduction of the sulphur dioxide content in a gas mixture containing at least 10% water by passing the gas mixture over a sulphur resistant hydrogenation catalyst in sulphidic form and thereafter through a dry oxidation bed for the oxidation of sulphur compounds to elemental sulphur. The reaction in the presence of the hydrogenation catalyst takes place in the presence of a reducing component in a molar ratio of reducing component to sulphur dioxide of more than 10 up to 100, at a temperature of 125°C to 300°C, and a space velocity of at least 2000 h<sup>-1</sup>. An advantage of the invention is that SO<sub>2</sub> can be selectively removed from the gas mixture by hydrogenation of the SO<sub>2</sub> without substantial reduction of other sulphur components such as elemental sulphur in the gas mixture to H<sub>2</sub>S. Thus, less capacity is required for the subsequent oxidation step.

The '547 patent describes a process that involves the reduction of all SO<sub>2</sub> and other reducible sulphur compounds from a

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Claus off-gas (see column 3, lines 45-49). The off-gas is led over a hydrogenation catalyst, preferably a Ni/Mo/Al<sub>2</sub>O<sub>3</sub> or Co/Mo/Al<sub>2</sub>O<sub>3</sub> (col. 5, line 23) together with a hydrogen containing gas. Thereafter, the formed H<sub>2</sub>S may be removed by a solution comprising an oxidising agent or a catalyst.

The '547 patent fails to teach or suggest the present invention as claimed. The '547 patent fails to teach or suggest carrying out the oxidation of sulphur compounds in a dry bed oxidation bed. Furthermore, in contrast to the Examiner's assertion, this cited art fails to teach or suggest carrying out the hydrogenation at a ratio of reducing agent to SO<sub>2</sub> in the range of 10-100.

In the '547 patent, the "at least 20% by volume of pure hydrogen" contemplated (at column 4, lines 15-17) relates to the amount of hydrogen in the hydrogen containing gas which is added to the Claus off-gas. It does not relate to the hydrogen content in the Claus off-gas as itself or to the combination of Claus off-gas and hydrogen containing gas which is passed over the reduction catalyst. The '547 patent is, thus, silent about the hydrogen content in the gas passed over the reduction catalyst and, in particular, does not suggest any suitable ratio of reducing agent (such as hydrogen) to SO<sub>2</sub> in that gas.

It is noted that according to the '547 patent, an excess (of unspecified magnitude) is preferred, yet not regarded as essential and, further, it is preferred that all the hydrogen-containing gas is added to an inline burner (see column 3, lines 49-57). One of ordinary skill in the art would understand that with "an excess," only a relatively small excess can be meant (e.g., of about 1%), in any case, an excess well below a ratio of 10. In particular,

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the skilled artisan would consider that, otherwise, the reaction conditions would have to be taken well outside the equilibrium reaction conditions to an extent that is not readily feasible (if possible at all) in combination with an in-line burner, as he would expect an unacceptable level of soot formation. Thus, the specific feature of a ratio of reducing agent to  $\text{SO}_2$  of 10-100 as defined in claim 1 of the present invention is not only not known, but this feature *per se* also renders the present claims non-obvious.

With regard to the step of oxidizing sulphur compounds in a dry oxidation bed, the process in the '547 patent involves the reduction of all  $\text{SO}_2$  and other reducible sulphur compounds by reaction with hydrogen into  $\text{H}_2\text{S}$  (col. 3, lines 45-49). Given the substantial amounts of other sulphur compounds such as elemental sulphur ( $\text{S}_n$ ), the off-gas will contain a high amount of  $\text{H}_2\text{S}$ , compared to the gas mixture in the present invention, after it has passed over the hydrogenation catalyst. Thus, the process in the '547 patent releases a high amount of energy when the  $\text{H}_2\text{S}$  is subsequently oxidised. This would not be a problem for the process in the '547 patent because the solvent's heat capacity will avoid an excessive temperature increase.

An ordinary skilled person in the art would, however, not consider replacing the oxidation in a solution by a dry bed oxidation. The dry bed would pose a risk of having an excessive temperature rise due to the presence of high amounts of  $\text{H}_2\text{S}$  after the reduction step in the process of the '547 patent and the reduced heat capacity of a dry bed in comparison to the solution. Taking into account that the conversion of 1 vol. %  $\text{H}_2\text{S}$  in a dry oxidation bed typically results in a temperature rise of about

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65°C, the presence of about 2-4 vol. % H<sub>2</sub>S (which is an expectable concentration range in a Claus off-gas, after treatment in accordance with the hydrogenation step of the process of the '547 patent) would lead to a temperature rise of about 130-260°C. The skilled person would understand that the oxidation of H<sub>2</sub>S would then be uncontrollable, leading to an undesirable reaction of H<sub>2</sub>S with oxygen back to SO<sub>2</sub>. Therefore, any teachings from the '547 patent and any obvious renderings of a skilled artisan as suggested by the Examiner would not be contemplated to carry out a process nor would any reasonable expectation of success be practicable according to the invention as claimed.

Kohl et al. fails to cure the deficiencies found in the '547 patent. As argued above, a skilled artisan would *prima facie* not consider replacing the oxidation in solution by a dry bed oxidation as this would be highly detrimental to the object of the process of removing SO<sub>2</sub> as claimed. Kohl et al. teaches that the dry oxidation is recommended for use at desulphurisation of high pressure gases containing less than 20 grains H<sub>2</sub>S/100 scf (see page 422, 2<sup>nd</sup> full paragraph), which corresponds to only about 0.032% H<sub>2</sub>S. Kohl et al. further describes that close moisture control is of the greatest importance (see page 424, 3<sup>rd</sup> full paragraph) and that the oxides containing less than 17% or more than 55% water do not function properly.

Based on the foregoing, a skilled artisan would not consider replacing the oxidation in solution of the process in the '547 patent by a dry bed oxidation because he would consider that the H<sub>2</sub>S content would be too high for the dry bed process and that such high H<sub>2</sub>S would lead to an excessive temperature increase, leading to evaporation of the moisture needed in the dry oxidation

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process of Kohl et al., and to a non-properly functioning oxidation process. Thus, the subject-matter of the present invention is not obvious, either alone or in combination of the '547 patent and Kohl et al.

Furthermore, Kohl et al. describes a discontinuous dry oxidation process (see page 423, where it is specified that the reaction is most satisfactorily carried out at temperatures below the solidification point of sulphur, namely at temperatures of 100-120°F). In contrast, the present invention is typically carried out in a continuous way. Moreover, the process of Kohl et al. is not considered advantageous because it results in huge amounts of waste materials that should quite often be taken out of the absorbers manually, at relatively short intervals which is not considered acceptable. Accordingly, Applicants respectfully request reconsideration and withdrawal of the foregoing rejection.

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CONCLUSION

Based on the foregoing, entry of the amendments and remarks presented herein, reconsideration and withdrawal of all the rejections and allowance of application with all pending claims are respectfully requested.

The Examiner is encouraged to telephone the undersigned attorney to discuss any matter that would expedite allowance of the present application.

Respectfully submitted,

JOHANNES BORSBOOM ET AL.

By: 

Charles L. Gagnebin III

Registration No. 25,467

Attorney for Applicant(s)

WEINGARTEN, SCHURGIN,

GAGNEBIN &amp; LEBOVICI LLP

Ten Post Office Square

Boston, MA 02109

Telephone: (617) 542-2290

Telecopier: (617) 451-0313

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